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Experimental studies on particle impaction and bounce: effects of substrate design and material

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Abstract

This paper presents an experimental investigation of the effects of impaction substrate designs and material in reducing particle bounce and reentrainment. Particle collection without coating by using combinations of different impaction substrate designs and surface materials was conducted using a personal particle sampler (PPS) developed by the University of Southern California. The PPS operates at flow rate of 4 l min^{-1} with a 50% cutpoint of approximately 0.9 μm in aerodynamic diameter. The laboratory results showed that the PPS collection efficiency for particles larger than 50% cutpoint is strikingly low (e.g., less than 50%) when an uncoated open cavity made of aluminum was used as an impaction substrate. The collection efficiency gradually increased when Teflon tape, Nuclepore, and glass fiber filters were used as impaction surfaces, respectively. Conical or partially enclosed cavity substrate designs increased collection efficiency of particles of 9 μm up to 80–90%. A conical cavity with glass fiber filter used as impaction surface was identified as the optimum configuration, resulting in a collection efficiency of 92% at Stokes numbers as high as 15.4 (corresponding to 9 μm in aerodynamic diameter). Particle losses were low (less than 10%) and relatively independent of particle size in any design with glass fiber filter. Losses seemed to increase slightly with particle size in all other configurations. Finally, outdoor PM_1 concentrations obtained with the PPS (in its optimum configuration) and a modified micro-orifice uniform deposit impactor (MOUDI) with coated impaction stages were in excellent agreement. The mean ratio of the PPS-to-MOUDI concentration was 1.13($\pm$0.17) with a correlation coefficient $R^2 = 0.95$. Results from this investigation can be readily applied to design particle bounce-free impaction substrates without the use of coating. This is a very important feature of impactors, especially when chemical analysis of the collected particulate matter is desirable.

Keywords: Impaction; Particle bounce and reentrainment; Personal sampling

1. Introduction

Impactors have been commonly used for the measurement of particle mass concentration and size distribution. To obtain accurate particle size distribution with an impactor, all particles colliding on the impaction surface must adhere to it. Errors in the size distribution measurement are introduced when dry solid particles bounce from previous stages and are collected in a subsequent filter stage (Dzubay et al., 1976; Markowski, 1984). Particle bounce depends on the nature of the impaction surface, the type and thickness of coating material, the type of particles, particle loading on the impaction surface, the sampling conditions and the designs of impaction substrate (Rao and Whitby, 1978a, b; Reischl and John, 1978; Chen and Yeh, 1979; Hinds, 1985; Turner and Hering, 1987; Wang and John, 1987; Newton et al., 1990; Pak et al., 1992; Tsai and Cheng, 1995). The minimization of particle bounce and reentrainment from

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impaction surfaces is therefore a critical factor to obtain reliable particle size distributions.

Some investigations have indicated that an impaction substrate coated with an adhesive material can reduce particle bounce and reentrainment at light particle loadings. However, the collection efficiency may significantly decrease with heavy loading since incoming particles bounce off previously deposited particles (Reischl and John, 1978; Turner and Hering, 1987; Oak et al., 1992). Reischl and John (1978) used an oil-soaked sintered metal disk as an impaction surface to prevent particle bounce from heavy loading and showed collection efficiencies approaching 100%, independently of particle loading. The oil's low viscosity provides the coating on collected particles by capillary action and the sintered metal disk serves as the oil reservoir, thereby preventing the oil from being blown away by the impinging jet. Turner and Hering (1987) used oiled membrane filters as impaction substrates. Their experimental data showed that substantially high collection efficiencies were achieved when coated 10 μm Teflon membrane filters were used, without any noticeable decrease when loading increased.

Work on reducing particle bounce is mostly restricted to conventional flat impaction surfaces, and some (for example, Pak et al., 1992) considered light loading only. For practical sampling purposes, it is very important to also consider heavy loadings. Few hundred layers of particles are deposited on the impaction surface during a 24-h aerosol sampling even at low flow rates (e.g. $4\ \mathrm{l\ min^{-1}}$). Even with the rotating stage designs such as the micro-orifice uniform deposit impactor (MOUDI) (Marple et al., 1991), several of tens of layers are expected under the same condition.

Uncoated impaction substrates are highly desirable, as they enable chemical and elemental analysis of the collected particulate matter that is free of interferences from coating materials. They are also more practical in high-temperature sampling conditions (Biswas and Flagan, 1988). Virtual impactors have been developed to prevent particle bounce and reentrainment problems. The major shortcoming of virtual impactors is penetration of particles smaller than the 50% cutpoint into the minor flow of the virtual impactor, and in some cases excessive wall losses (Marple and Chien, 1980; Chen et al., 1986; Chen and Yeh, 1987).

Biswas and Flagan (1988) extended the concept of Schott and Ranz (1976) and designed a particle trap impactor, in which particles impacted on a quiescent cavity. Collection efficiencies of 80 to 85% were achieved at Stokes numbers as high as 1.5 with an uncoated cavity. Particle bounce was not examined for higher Stokes numbers. In addition, possible wall losses as well as the variation of collection efficiencies with time were not explicitly described in the paper.

Tsai and Cheng (1995) designed cavity-type impaction substrates similar to Biswas and Flagan's particle trap impactor and studied the effects of cavity designs, coating and particle loading on particle bounce. The results indicated that unless the substrate is greased, particle bounce cannot be eliminated. That study was performed exclusively with aluminum impaction surfaces, and the effect of impaction substrate material was not examined.

The aforementioned investigations were conducted either only with different coated collection surfaces or impaction substrate designs to reduce particles bounce and reentrainment. In this study, we investigated the possibility of achieving high particle collecting efficiency on uncoated substrate surfaces by developing different substrate configuration designs and varying substrate surfaces, an optimum configuration was identified. The laboratory and field tests identified an optimum configuration, resulting in minimum particle bounce, which we will use in future work to design improved cascade impactors. The use of uncoated impaction surfaces is of particular importance when chemical analysis of the collected particulate matter is desirable.

2. Methods

2.1. Impactor design

The impactor used in this experimental investigation was a personal particle sampler (PPS) described in more detail by Sioutas et al. (1998). The PPS, shown in Fig. 1, consists of the following four components: (1) an inlet that removes particle approximately larger than 15 – 20 μm in an aerodynamic diameter; (2) the acceleration nozzle block; (3) the impaction substrate block; (4) the filter holder.

Aerosols are drawn into the PPS through four orifices, positioned radially at 90°. Each orifice is 0.37 cm in diameter. The particle jet velocity through the orifice is approximately $155\ \mathrm{cm\ s^{-1}}$ at a sampling flow rate of $4\ \mathrm{l\ min^{-1}}$. The orifice were designed so that particle larger than about 15 μm in aerodynamic diameter impact on a coated cylinder made of porous stainless steel (100 μm pore size, 1.9 cm in outside diameter and 1.6 cm long).

The porous cylinder is mounted on the acceleration nozzle block of the impactor. The acceleration nozzle diameter was 0.14 cm. The choices of the sampling flow as well as the nozzle design parameters were made so that the predicted 50% cutpoint of the impactor is about 1.0 μm in aerodynamic diameter. The principle parameter determining particle capture is the Stokes number of a particle having a 50% probability of impacting, St_{50}, defined as the ratio of the product of the jet velocity, U, and the particle relaxation time, τ, vs. the impactor's nozzle diameter, W, (Hinds, 1982)

$$St_{50} = \frac{2\tau U}{W} = \frac{\rho_p C_c d_{50}^2 U}{9\mu W}, \tag{1}$$

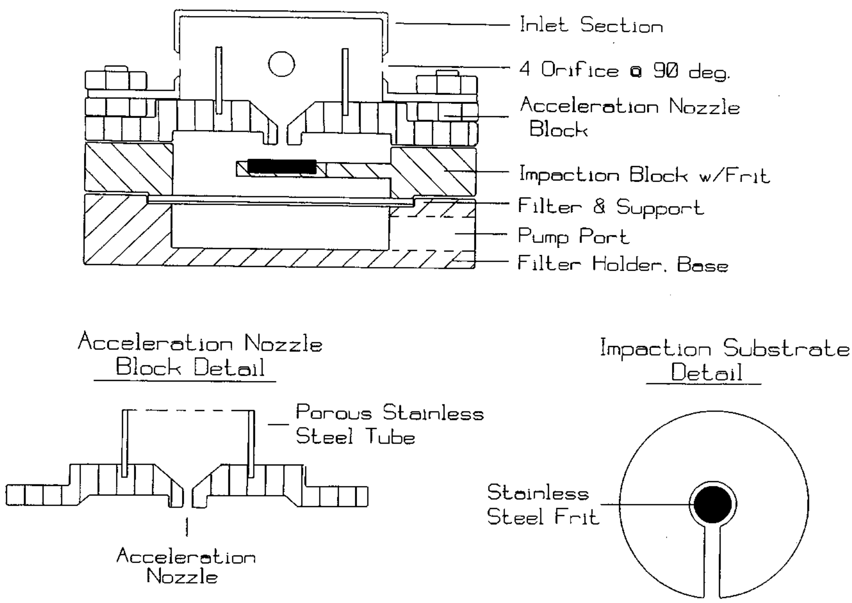

Fig. 1. Schematic diagram of the personal particle sampler (PPS).

where d_{50} is the geometrical diameter of particle having a 50% probability of impacting, U is the average velocity of the jet (cm s^{-1}), ρ_p is the particle density (g cm^{-3}), μ is the dynamic viscosity of the air (g cm^{-1} s^{-1}), and C_c is the Cunningham slip correction factor. The slip correction factor is given by the equation (Hinds, 1982)

$$C_c = 1 + \frac{2}{Pd_p}[6.32 + 2.01 \exp(-0.1095Pd_p)], \quad (2)$$

where P is the absolute pressure upstream of the impaction zone (in cmHg) and d_p is the particle diameter in μm. For the aforementioned values for U, W, and P, the St_{50} value corresponding 1.0 μm is approximately 0.2.

The impaction substrate block was designed as shown in Fig. 2. It consisted of a thin hollow aluminum disk of 0.95 cm in diameter placed at a distance of 0.3 cm away from the exit of the acceleration nozzle. In its standard configuration (as described by Sioutas et al., 1998), a porous metal disk (100 μm pore size, 0.95 cm in diameter and 0.16 cm thick) is inserted tightly in the hollow aluminum disk. The porous disk is impregnated in mineral oil to minimize particle bounce. In addition to this configuration, three different impaction substrate designs, shown in Fig. 2, were tested. Design 1 is an open cavity, formed by inserting a metal ring with an external diameter of 0.95 cm and internal diameter of 0.4 cm into the hollow aluminum disk. Design 2 is a conical cavity with the same opening of 0.4 cm with that of Design 1. Design 3 is a partially-enclosed cylindrical cavity whose opening has the same diameter (e.g., 0.4 cm) with that of the previous two configurations. The 0.4 cm-opening of the cavities is approximately three times the diameter of the acceleration nozzle.

As mentioned in previous paragraph, another objective of our research was the effect of the substrate material on collection efficiency. The bare aluminum surface on the hollow disk was the base material. Three other different materials were tested: (a) glass fiber filter (Gelman, 2 μm pore, Ann Arbor, MI); (b) Nuclepore filter (Costar, 0.4 μm, Cambridge, MA), and; (c) Teflon tape (Scienceware, Peguannock, NJ). Disks of 0.95 cm in diameter were made of each material in order to fit in the hollow disk of the substrate. The disks were placed on top of the aluminum substrate without any coating. A tight fit between the substrate cavity and the rings kept the impaction disks in place during the experiment.

The fourth component of the sampler was a filter holder designed to hold standard 37 mm filters. The four pieces were held together and compressed tightly to provide leak-free sealing with four centering bolts.

2.2. Experimental characterization

The experimental setup for testing the effects of substrate surface designs and materials is shown in Fig. 3. Monodisperse aerosols were generated by atomizing dilute aqueous suspension of fluorescent polystyrene latex particles (Fluoresbrite, Polysciences, Warrington, PA), ranging from 0.5 to 9.0 μm, using a constant output nebulizer (HEART, VORTRAN Medical Technology,

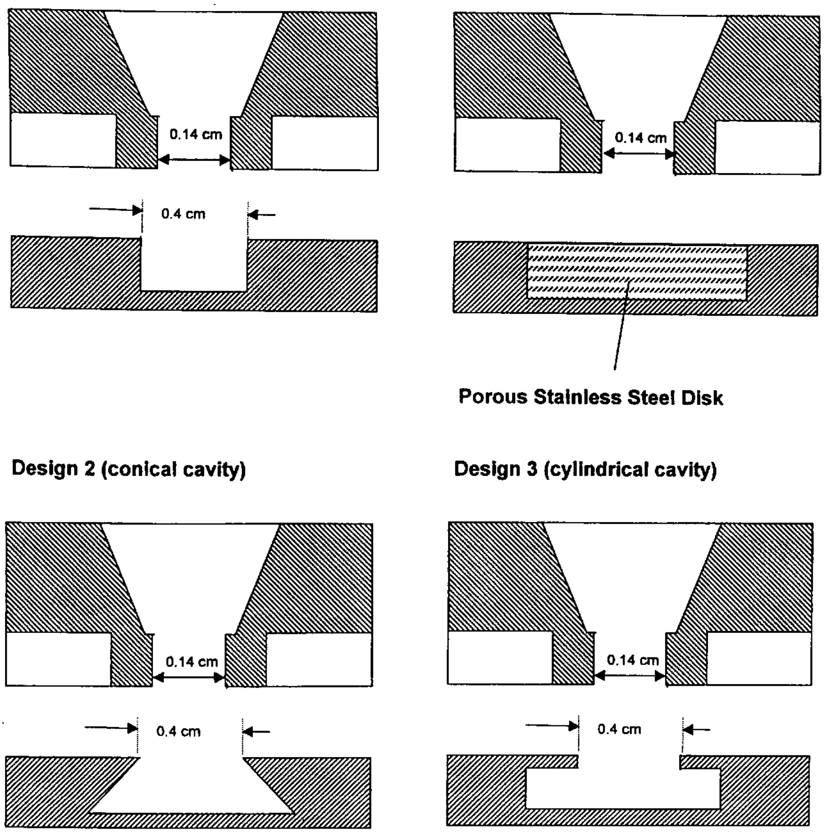

Fig. 2. Schematic representation of the different impaction substrate designs tested in the laboratory experiments.

Inc., Sacramento, CA). All the generated particles were drawn through a 1-l bottle to remove excess moisture and mixed with room dry air afterward. The temperature (T) and relative humidity (RH) of the dry aerosol was monitored continuously throughout the experiments with a T/RH probe (Cole-Parmer® Model 37960, Cole-Parmer® Instruments Co., Vernon Hills, IL). In all experiments, the relative humidity ranged from 25 to 40%.

The dry aerosols were then drawn through a Po-210 neutralizer (NDR Inc., Grand Island, NY) that reduced particle charges before entering the PPS. A 37 mm Teflon filter (Gelman, 2.0 μm pore, Ann Arbor, MI) was placed in the filter holder downstream of the impaction substrate. For each particle size, combinations of different substrate designs and materials in the impaction substrate block were examined. In each experiment, the collected particles on the substrate plate and Teflon filter were extracted in 3 ml ethyl acetate. The acceleration nozzle was washed with 3 ml of ethyl acetate to determine wall loss. The quantity of fluorescent dye was measured by fluorescence detector (FD-500, GTI, Concord, MA). The collection efficiency of the impactor is determined as

$$\text{Collection efficiency} = \frac{C_{\text{sub}}}{C_{\text{sub}} + C_{\text{fil}}}, \tag{3}$$

where C_{sub} and C_{fil} are the concentrations of fluorescence for the substrate impaction surface and the 37 mm glass fiber filter, respectively. Particle loss is determined as following:

$$\text{Particle loss} = \frac{C_{\text{wall}}}{C_{\text{sub}} + C_{\text{fil}} + C_{\text{wall}}}, \tag{4}$$

where C_{wall} is the concentration of fluorescence washed from the surfaces of the acceleration nozzle (e.g., the throat of the jet and the backside of the nozzle plate). Particle loading varied from approximately 0.15 to about 5 mg.

2.3. *Field study*

The experimental tests identified an optimum configuration of impactor substrate design and material resulting in minimum particle bounce. This configuration of

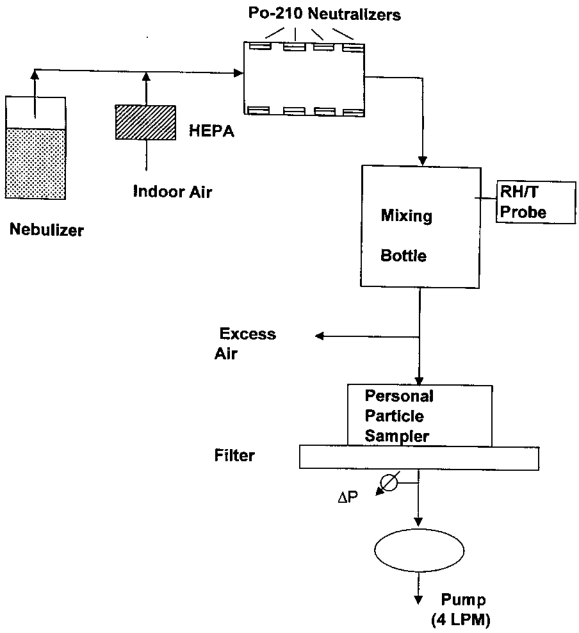

Fig. 3. Schematic diagram of the test apparatus used for the experimental characterization of the personal particle sampler (PPS) with combinations of substrate designs and surfaces.

the PPS was used in collocation with a micro-orifice uniform deposit impactor (MOUDI, MSP Corporation, Minneapolis, MN) in a field study conducted in the environment of the University of Southern California in July 1998. The MOUDI operated at 30 $\mathrm{l\,min^{-1}}$ and it typically classifies particles in 10 aerodynamic diameter intervals, from 0 to 10 μm. In our field study, however, we only used the following stages: (1) the inlet stage to remove coarse particles (serving the same purpose as the orifice of PPS); (2) the 1.0 μm cutpoint stage (collecting particles larger than 1 μm; and; (3) a 37 mm Teflon after-filter (Gelman, 2 μm pore, Ann Arbor, MI) which collects all the particles smaller than 1.0 μm in aerodynamic diameter. The two MOUDI stages were coated with silicon lubricant (Chemplex 710, NFO Technologies, Kansas City, KS) to minimize particle bounce. Thus, the modified MOUDI was used as a reference sample for measurement of the true concentration of ambient particle smaller than 1.0 μm in aerodynamic diameter (i.e. PM_1).

The sampling flow rates of PPS and MOUDI were measured with calibrated mass flow meters (Cole–Palmer Instruments, Vernon Hills, IL). The Teflon filters were weighed before and after each field test in a Mettler 5 Microbalance (MT 5, Mettler Toledo Inc., Highstown, NJ) under controlled relative humidity and temperature conditions in order to determine the mass concentration measured by the different samplers. A 24-h time period was allowed after sampling for the filter equilibration. Laboratory and field blanks were used for quality assurance. Filter and filter blanks were weighed twice in order to increase precision. If during filter weighing, a difference of more than 2 μm between consecutive weighings was observed, a filter was weighed for a third time.

3. Results and disccusion

3.1. Collection efficiency and losses

Figs. 4a–c, represent the collection efficiencies and losses respective to substrate designs 1, 2, and 3. In each figure, efficiencies and losses are plotted as a function of aerodynamic diameter for four substrate surface materials.

In Fig. 4a, Design 1 (open cavity with an aluminum surface) displays particle collection efficiency characteristics that are similar to those of a flat uncoated substrate surface. The collection efficiency for particles larger than the 50% cutpoint (e.g., 1 μm) is strikingly low. Specifically, the collection efficiency decreases from 55–35% when particle size increases from 1.0 to 9.0 μm, due to particle bounce. In the same configuration (Design 1), particle collection efficiency is greatly improved when original aluminum impaction surface is replaced by different materials. Particle collection efficiencies of about 60–75%, 60–80%, and 72–80% were achieved for particles in the range of 2–9 μm when Teflon tape, Nuclepore and glass fiber filters were used, respectively.

Fig. 4b presents the performance of PPS when Design 2 (conical cavity) replaced Design 1 with different substrate materials. The collection efficiency for each material increased by approximately 10%. Specifically, the collection efficiency ranges from approximately 75 – 90% for Nuclepore filter, and from approximately 65 – 80% for Teflon tape, respectively. A significant improvement on aluminum surface was also observed for particle size larger than 2 μm. The collection efficiency ranged from 80 – 90% as particle size increases from 2 – 9 μm. When the glass fiber filter was used as impaction substrate surface, the minimum collection efficiency was 90% or higher for particles larger than 3 μm in aerodynamic diameter. These results indicate a drastic reduction in particle bounce for the conical cavity substrate.

When the partially enclosed cylindrical cavity (Design 3) was used, Teflon tape had the lowest collection efficiency (from about 60 – 80%) for particles in the range of 2–9 μm. Similar to the results with Design 2, both aluminum and Nuclepore filter have higher collection efficiencies, ranging from about 75 – 90% for particles in the range of 2 – 9 μm. A collection efficiency of 85 – 90% on

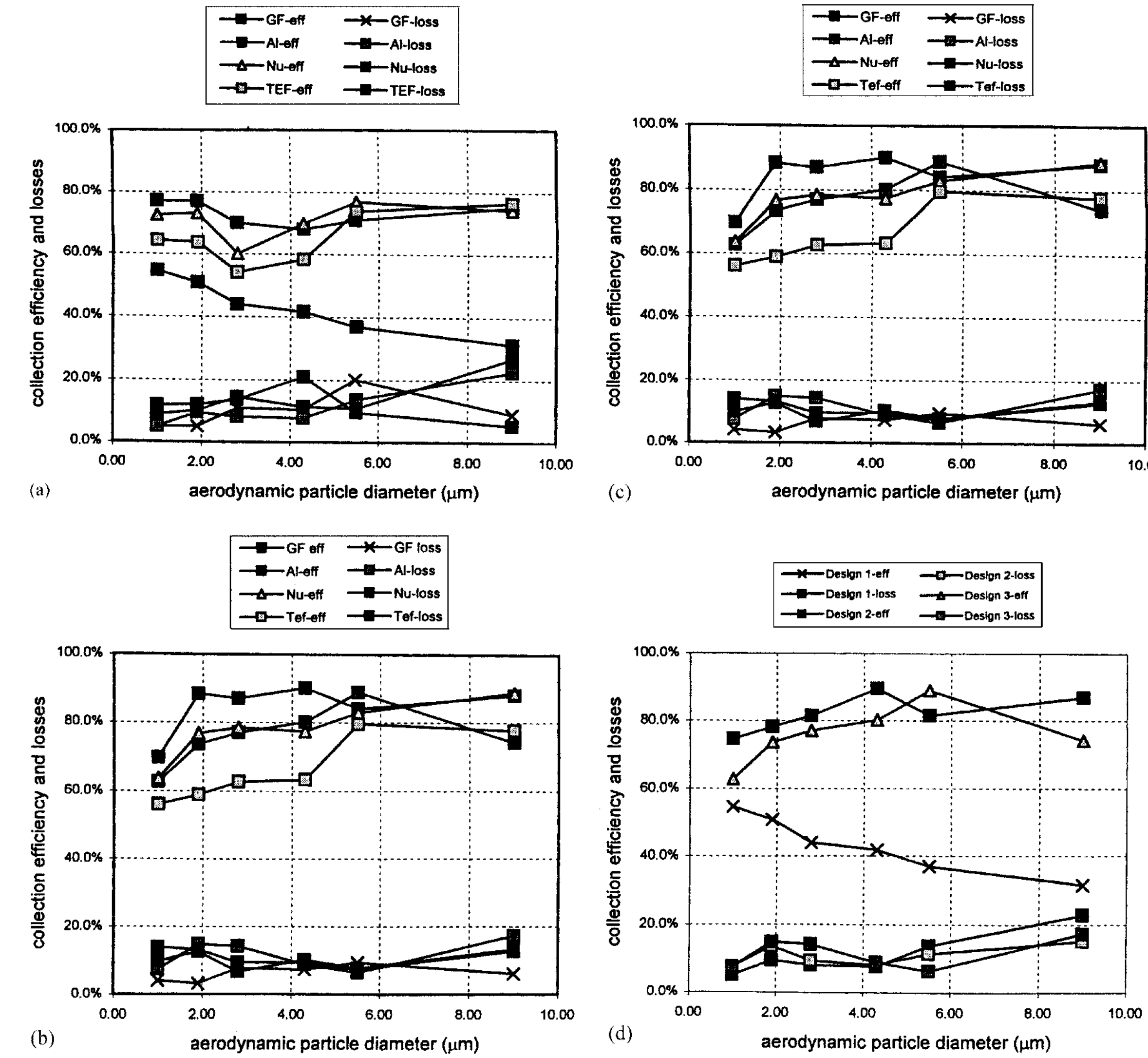

Fig. 4. Particle collection efficiency and losses of the PM_1 personal particle sampler (PPS) with different substrate designs and surface materials. Tests were conducted with monodisperse fluorescent polystyrene latex particles.

glass fiber filter is observed again for particles larger than 2.0 μm. In all three configurations, particle collection efficiency generally increases with particle size.

The results of Fig. 4 illustrate the effect of substrate surface materials on particle collection efficiency by impaction. For any substrate design, the glass fiber filter substrate displays superior characteristics in terms of minimizing particle bounce. The improvement in collection efficiency for glass fiber is probably due to the mat structure in glass fiber filter. Apparently, the impacting air streamlines penetrate partially the fiber mat thereby decreasing particle bounce. Similar observations were made by Willeke (1975) in experiments performed to characterize a high-volume slotted cascade impactor (Sierra Instruments, Model 235). Aluminum, Nuclepore filter and Teflon tape surfaces are smoother compared to glass fiber, thus less penetration of the impinging jet occurs for these surfaces.

The substrate design also affects the collection efficiency. This is best illustrated in Fig. 4d, showing the collection efficiency on the bare aluminum surface with different designs. Particle bounce is especially severe in an open cavity, whereas the conical and partially enclosed cavity designs seem to effectively trap impinging particles that would otherwise bounce. There is no significant difference between Designs 2 and 3, as they display similar collection efficiencies independently of substrate materials or particle size.

Particle losses range from 5 – 28% for aluminum surface and Nuclepore filter and, 5 – 12% for glass fiber and Teflon tape in Design 1. In all cases, they seem to increase with increasing aerodynamic diameter, probably due to inertial deposition on the walls of the acceleration jet. In Designs 2 and 3, the overall particle losses are lower than those of Design 1, ranging from 5 – 15%. Apparently, some of the particles bouncing from the impaction substrate of Design 1 have enough momentum to deposit on the back of the acceleration nozzle plate, rather than being collected by the after-filter of the impactor. An increasing trend with particle size is observed for both Nuclepore and Teflon filter substrates, whereas losses are somewhat independent of particle size on glass fiber filter.

A comparison between the particle collection efficiency and losses of Design 2 (with glass fiber as substrate surface material) and those of the standard coated substrate surface of the PPS is shown in Fig. 5. The collection efficiency of the coated substrate increases rapidly from 50 – 95% as particle size increases from 1 – 9 μm. The collection efficiency slightly decreases to about 85% when particle size becomes higher than 6.0 μm, presumably due to some particle bounce that may still occur despite the use of coating (Sioutas et al., 1998). As discussed in earlier paragraphs, particle bounce would be more severe for larger particles. Fig. 5 also indicates that the collection efficiency of the uncoated conical cavity with the glass fiber substrate is significantly higher than that of the coated substrate, for particles in the range of 0.8–2.5 μm. This is probably due to the partial entrainment of the air streamlines into the fibrous mat, which, along with reducing particle bounce, apparently increases the probability of collecting particles around the 50% cutpoint of the impactor. This additional deposition occurs by interception of particles on streamline penetrating into the fiber mat (Turner and Hering, 1987). Nevertheless, the experimental results shown in Fig. 5 indicate that this additional deposition does not decrease the sharpness in the cut characteristics of the PPS. In fact, the collection efficiency curve for Design 2 is slightly sharper than that of the coated substrate.

It should be noted that in the study by Tsai and Cheng (1995), particle collection efficiency decreased to approximately 80–85% when the particle Stokes number became higher than about 0.8, even when a coated trap-like substrate design was used. When the same configuration was used without coating, the highest collection efficiency was achieved close to St_{50}, but decreased to about 60–70% for Stokes numbers greater than 0.8. In comparison, Designs 2 and 3 (conical and partially enclosed cavities) with uncoated glass fiber filters as the substrate resulted in particle collection efficiency as high as 90% for a Stokes number of 15.4 (corresponding to 9.0 μm in aerodynamic diameter). Also, collection efficiencies were still 80% or higher for particles larger than 2.0 μm when

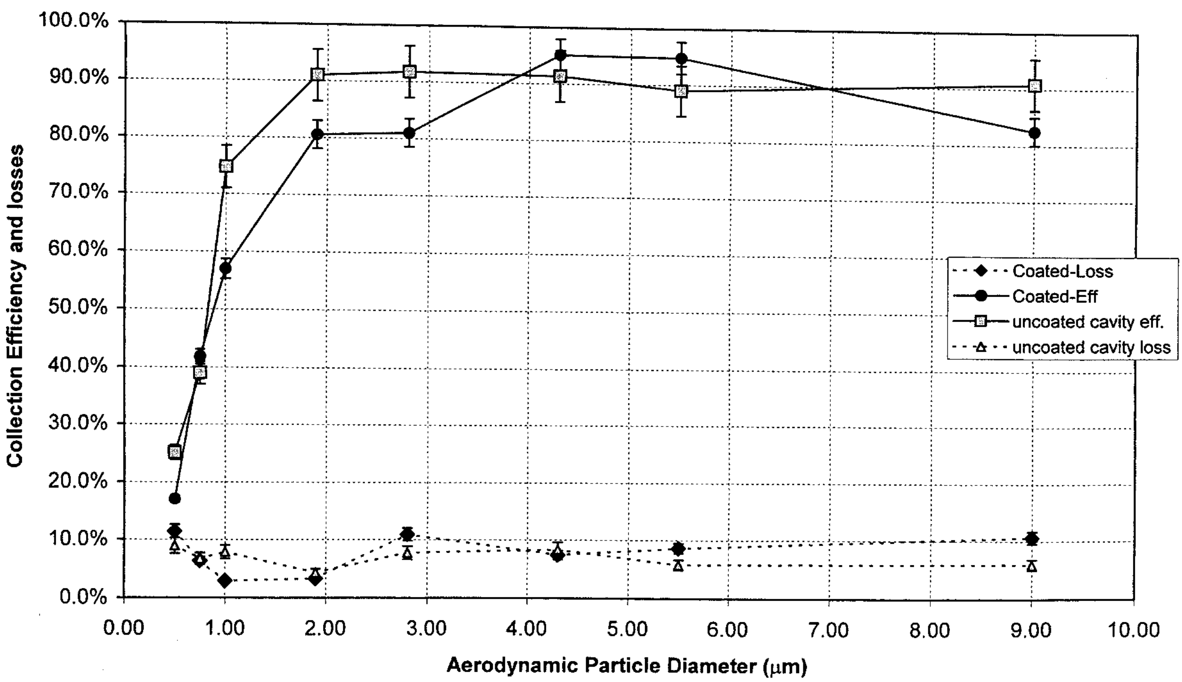

Fig. 5. Particle collection efficiency and losses of PPS with coated flat substrate surface and substrate Design 2 (conical cavity) with uncoated glass fiber filter surface.

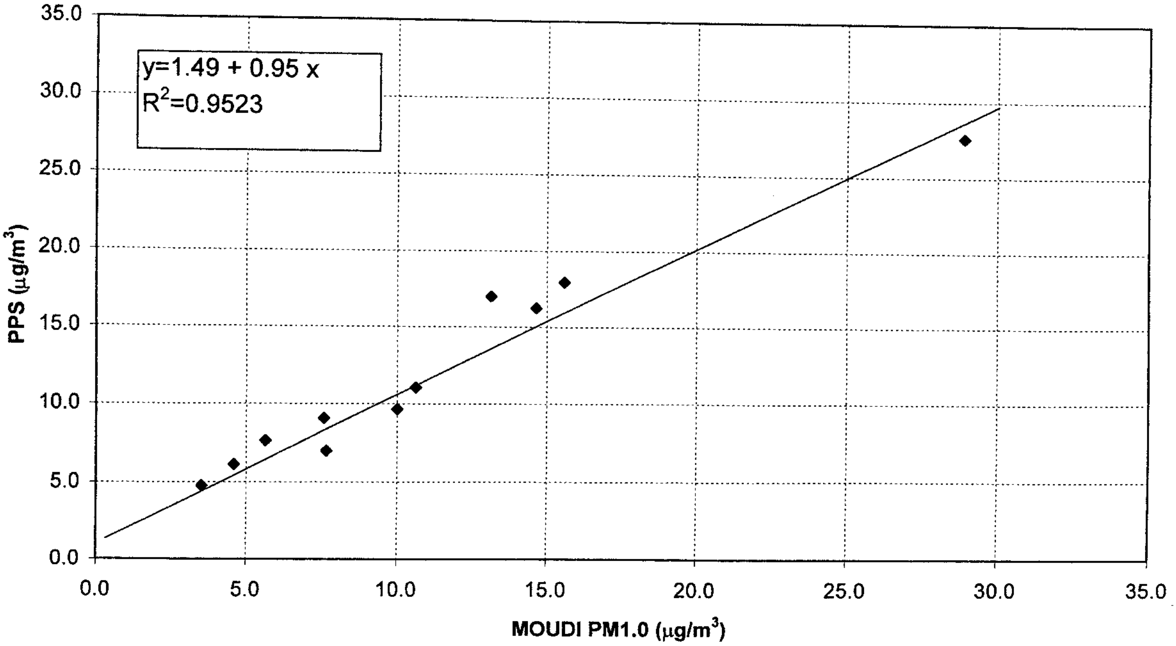

Fig. 6. Mass concentrations obtained with the PM_1 personal particle sampler (PPS) and the modified micro-orifice uniform deposit impactor (MOUDI) in the field study.

Table 1
Mass concentrations range, ratio and limits of detection (LOD) for the PPS and modified micro-orifice uniform deposit impactor (MOUDI) in the field study

	Concentration range ($\mu g\ m^{-3}$)	Concentration ratio (Mean $\pm$ S.D.)[a] (PPS/MOUDI)	Limit of detection ($\mu g\ m^{-3}$)[b]
PM_1 PPS	4.8–27.8		3.1
MOUDI	3.5–28.9	1.13($\pm$0.17)	0.42

[a]Average ration (mean $\pm$ standard deviation).
[b]Sampling duration of 8 h.

Nuclepore filter and aluminum substrates were used. Using a Teflon tape as impaction substrate resulted consistently in the lowest collection efficiency (range of 60–75%) for any substrate design.

It should also be noted that all of the laboratory tests in this study were conducted using polystyrene latex particles, which are considered particularly bouncy. We expect that, for any of the substrate designs that we tested, particle bounce would be less severe when “real-life” ambient aerosols are sampled.

3.2. Field study

As the experimental tests identified Design 2 (conical cavity combined with glass fiber as the substrate surface material) as an optimum configuration, this PPS design was used in the field study. Fig. 6 and Table 1 summarize the results of PPS and MOUDI field evaluation. Table 1 compares the ratio of PM_1 (e.g., mass concentration of particle smaller than 1.0 μm in aerodynamic diameter) obtained with the PPS and the modified MOUDI. The limits of detection for each sampler were determined by the following equation (Koutrakis et al., 1988):

$$\mathrm{LOD} = 3 * \mathrm{NL} * (V_s)^{-1}, \tag{5}$$

where NL is the standard deviation of the field blanks measured by gravimetric analysis and V_s is the total volume sampled in each of the experiments of the specific study. The value of NL is 2 μg. The average

PPS-to-MOUDI PM_1 mass concentration ratio is 1.13 ($\pm$ 0.17).

The PM_1 concentrations measured by the PPS are plotted against those obtained with the modified MOUDI in Fig. 6. The results show that the concentrations are highly correlated with R^2 value of 0.95. As the MOUDI substrates are coated, particle bounce is presumably eliminated, thus the MOUDI concentrations reflect the true ambient PM_1 concentrations. The excellent agreement in the PM_1 concentrations obtained with the two samplers indicates that a conical substrate design with an uncoated glass fiber filter can be potentially used as a particle bounce-free impaction substrate.

4. Summary and conclusion

The ability to reduce particle bounce and reentrainment by the combinations of different substrate designs and substrate surface materials in a conventional impactor was investigated in laboratory and field tests. The sampler used in this evaluation was a personal particle sampler (PPS) with 1.0 μm cutpoint operating at 4 l min^{-1}.

Three different substrate designs were used in conjunction with four different substrate surface materials. In Design 1 (open cavity), the collection efficiency is smaller than 55% for particles larger than about 1.0 μm when aluminum is used as an impaction surface. The collection efficiency is improved to an average of 70% by using either Nuclepore filter or Teflon tape as the substrate surface and further increased to 75% by using glass fiber filter as impaction substrate surface.

When a conical cavity (Design 2) and a partially enclosed cylindrical cavity (Design 3) were used, the collection efficiencies with Nuclepore filter and Teflon tape increased by an average of 10–15% compared to those in Design 1. For the aluminum surface, both Designs 2 and 3 reduced particle bounce dramatically. The collection efficiency increased up to 92% for particles as large as 9.0 μm in aerodynamic diameter when uncoated glass fiber filter was used as the impaction substrate material. There is no obvious difference in the collection efficiencies between the conical and the partially enclosed cavity designs for any substrate material.

Particle losses are low (e.g., 10% or less) when glass fiber is used in conjunction with conical or partially enclosed cavity substrate designs, and seem to be independent of particle size. For substrate surface materials other than glass fiber, particle losses range from 5 – 28% and generally tend to increase with particle size.

In a field study, the PM_1 mass concentrations obtained with the PPS with an uncoated conical cavity substrate design combined with glass fiber surface and a modified PM_1 MOUDI with coated substrates were in excellent agreement. The average ratio of the PPS-to-MOUDI PM_1 concentration was 1.13($\pm$ 0.17). In addition, the mass concentrations obtained with the two samplers were highly correlated with R^2 value of 0.95.

The results of this investigation indicate that proper designs of the impaction substrate and the choice of its material may significantly reduce particle bounce and reentrainment. The ability to use uncoated impaction substrates is a highly desirable feature of impactors, as the collected particulate matter can be analyzed chemically without any interference from the coating material. This is particularly important in impactors operating at relative low flow rates (i.e., 5 l min^{-1} or less), such as personal samplers, in which the total particulate matter collected over short-time periods (i.e. 24 h or less) on the substrate may not exceed few tens of micrograms.

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